

In the United States Patent and Trademark Office

Serial No. _____

Appn. Filed : _____

Applicant: Yuri Glukhoy

Appn. Title: AEROSOL MASS SPECTROMETER FOR OPERATION IN A HIGH-DUTY MODE AND METHOD OF MASS-SPECTROMETRY

Examiner/GAU: _____

Mailed: Feb. 28/04
At: San Carlos, CA

Information Disclosure Statement

Commissioner for Patents

P.O. Box 1450, Alexandria, VA 22313-1450

Sir:

"Industrial Plasma Engineering" by Reece Roth, Vol. 1, Institute of Physics Publishing, Bristol and Philadelphia, 1992, pp. 206-218, describes sources of charged particles suitable for use in mass spectrometers.

US Patent No. 5,396,065 issued in 1995 to C. Myerholtz, et al. discloses an encoded sequence of charged-particles in packets for use in time-of-flight mass spectrometers, in which the high-mass charged particles of a leading packet will be passed by the low-mass charged particles of a trailing packet. However, the method and apparatus of the aforementioned patent make interpretation of obtained data more complicated and not easily comprehensible. Furthermore, additional electronic circuits are required for control

of the charged particle packet sequence. However, such method and apparatus make interpretation of obtained data more complicated and not easily comprehensible. Furthermore, additional electronic circuits are required for control of the charged particle packet sequence.

US Patent No. 5,753,909 issued in 1998 to M. Park et al. describes a method and apparatus for analyzing charged particles by determining times of flight including using a collision cell to activate charged particles toward fragmentation and a deflector to direct charged particles away from their otherwise intended or parallel course. A disadvantage of this device consists in that it is based on the selection of specific charged particles and does not show the entire mass spectrum. For obtaining the entire spectrum, it is necessary to perform step by step scanning, and this requires an additional time. A disadvantage of the device disclosed in US Patent No. 5,753,909 consists in that this mass spectrometer is based on the selection of specific charged particles and does not show the entire mass spectrum. For obtaining the entire spectrum, it is necessary to perform step by step scanning, and this requires an additional time.

US Patent No. 6107,625 issued in 2000 to M. Park discloses a coaxial multiple reflection time-of-flight mass spectrometer of a time-of-flight type with resolution capacity improved due to a longer time of flight of the charged particles. The apparatus comprises two or more electrostatic reflectors positioned coaxially with respect to one another such that charged particles generated by a charged-particle source can be reflected back and forth between them. This system with storage of charged particles does not allow a continuous mode of mass analysis. The data is difficult to interpret, especially when masses of charged particles are scattered in a wide range.

U.S. Patent Application No. 10/058,153 filed by Yu. Glukhoy on January 29, 2003 discloses a quadrupole mass spectrometer that provides extended time of flight trajectory and hence a very high time resolution. A mass spectrometer of the aforementioned patent application is based on the use of quadrupole lenses with an angular gradient of the

electrostatic field from lens to lens. The charged particles perform flights in direct and reverse directions along helical trajectories. However, the above-described helical-path quadrupole mass spectrometer, as well as all aforementioned known mass spectrometers of other types, is not very convenient for aerosol applications and is not suitable for operation in a continuous mode.

Different methods used for reconstruction of the particle distribution spectra in acquisition period of the cycle of mass spectrometer are described in the following literature sources: 1) G. Wilhelmi, et al. in "Binary Sequences and Error Analysis for Pseudo-Statistical Neutron Modulators with Different Duty Cycles," Nuclear Inst. and Methods, 81 (1970), pp. 36-44; 2) Myerholtz, et al. "Sequencing ion packets for ion time-of-flight mass spectrometry" (see aforementioned US Patent 5,396,065 described earlier in the description of the prior art); 3) Cocg "High duty cycle pseudo-noise modulated time-of-flight mass spectrometry" (US Patent 6,198,096, issued March 6, 2001; 4) Brock, et al. "Time-of-flight mass spectrometer and ion analysis" (US Patent 6,300,626, issued October 9, 2001); 5) Overney, et al. "Deconvolution method and apparatus for analyzing compounds" (US Patent 6,524,803, issued February 25, 2003), etc. The above methods utilize special properties of the pulsing sequence, e.g., a pseudo-random binary sequence (PRBS) or Hadamard Transform. However, they cannot reach a high duty-cycle because their TOF MS's annihilate a part of the flow of charged particles by a gating grid [see references 3) and 4)] or deflecting mesh [see reference 5)] during binary modulation that they converted. This is because at least a half of the charged-particle flow must be discarded to allow the other half to be counted. The flow of charged particles sputters and contaminates the modulation grids or meshes and creates secondary electron-, ion-, or photon-emission leading to deterioration of the grids. Furthermore, foreign species introduced in the drift space because of contamination and sputtering destruct the detectors and distort the information. The low sensitive flat deflection system, which is used in the in the A. Brock et al TOF-MS for the Hadamard's transform, contains a high density array of the wires with alternating potential that leads to breakdown.

The disadvantages of all known aerosol TOF MS's make them unsuitable for aforementioned high-duty analysis under extreme or critical conditions such a biological attack or an environmental disaster, e.g., a hazardous leakage or contamination of water reservoirs in populated areas.

Thus, none of the aforementioned references discloses, as claimed in my main Claim 1 with dependent Claims 2-27, an aerosol TOF MS with a quadrupole lens system that provides alternating deflections of the flow of particles between two positions for aligning the flow with two inlet openings into the TOF MS so that the TOF MS of the invention can be used in continuous and high-duty applications with the duty cycle as high as 98%, which is unattainable with any known device of this class. Furthermore, none of the aforementioned references discloses, as claimed in my main Claim 28 with dependent Claim 29, a method of mass spectrometry with the use of an aerosol time-of-flight mass spectrometer that receives a flow of charged particles for analysis, wherein the flow of particles is divided into at least two flows of randomly modulated charged particles and are alternatingly directed to at least two injection opening for flying along separate trajectories for independent analysis without mutual interference.

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Yuri Glukhoy

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1. "Industrial Plasma Engineering" by Reece Roth, Vol. 1, Institute of Physics Publishing, Bristol and Philadelphia, 1992, pp. 206-218

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